U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 233.

Experiment Station Work,

XXXI.

Compiled from the Publications of the Agricultural Experiment Stations.

ROOT SYSTEMS OF PLANTS.
FERTILIZERS FOR ASPARAGUS.
MUSHROOM CULTURE.
ONIONS IN THE SOUTHWEST.
ETHER FORCING OF RHUBARB.
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MILK FROM DISEASED COWS.
CIDER VINEGAR.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.

A. C. TRUE, Director.

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EXPERIMENT STATION WORK.

Edited by W. H. BEAL and the Staff of the Experiment Station Record.

Experiment Station Work is a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. TRUE, Director, Office of Experiment Stations.

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EXPERIMENT STATION WORK.[a]

THE ROOT SYSTEMS OF FIELD CROPS.[b]

The root systems of our cultivated plants bear a most important relation to the cultivation of the crops, the application of fertilizers, and the moisture content of the soil; and in order to understand fully the reasons for the different cultural practices it is really necessary to know to what extent and in what way the roots of the various crops develop. That the development of the root systems of our common cereal and forage crops is not so well understood as might be supposed is demonstrated by the fact that samples of plants prepared with a view to showing the lateral as well as the downward extension of the entire root system in its natural position always arouse great interest in observers of all classes, and even cause surprise to persons who have spent their whole lives upon the farm, and in many cases growing these very crops year after year. Such samples were exhibited at the World's Fair in Chicago in 1893, in Paris in 1900, and in St. Louis in 1904, and in every instance they proved to be most instructive object lessons.

The natural distribution of the roots of most of our common field crops has been studied among others by the Wisconsin, North Dakota, Kansas, and Minnesota experiment stations, and these institutions also prepared the samples which attracted so much attention at the different expositions. The bulletins on the results of these investigations, published from time to time, are here summarized for the purpose of collecting the data with reference to all the crops under experiment.

In studying the natural distribution of the roots of different field crops the plants are grown in the field in the ordinary way. At the time the root samples are to be prepared a trench 2 feet wide and several feet deep is dug about the block of earth containing them. A wooden or iron frame is closely fitted over this block of earth and the

[a] A progress record of experimental inquiries, published without assumption of responsibility by the Department for the correctness of the facts and conclusions reported by the stations.

[b] Compiled from Wisconsin Sta. Rpts. 1892, p. 112; 1893, p. 160. New York State Sta. Rpt. 1888, p. 171. North Dakota Sta. Buls. 36, 43, 64. Kansas Sta. Bul. 127. Colorado Sta. Rpt. 1896, p. 181. Minnesota Sta. Bul. 5.

sides of the same are covered with common wire poultry netting. When this cage is properly fitted the top part of the frame rests firmly on the surface of the ground about the base of the plants, and plaster of Paris, reduced to a thin paste with water, is then poured into it and allowed to set and harden. Small rods made from No. 10 or No. 12 galvanized-iron wire, straightened and cut into pieces about 2 inches longer than the width of the cage and sharpened at one end, are then run through the block of earth one way, or both ways when the cage is square, and secured by looping the blunt end around the wire netting. The arrangement of the rods is such that when the earth is removed the roots and root fibers are held in practically the same positions they occupy in the soil at the time of growth.

After the rods are fixed the earth is slowly and carefully washed away by applying water through a small force or spray pump and the roots left suspended on the wire rods. The hardened plaster of Paris represents the surface of the ground and supports the upper parts of the plant. This method requires no artificial preparation of the soil before planting the crop, and the samples secured show the actual development and distribution of the roots under natural field conditions.

Corn root system.—At the Wisconsin Station samples of corn taken 42 days after planting, when the tops were about 18 inches high, showed that the roots of 2 hills met and passed each other in the center of rows 3½ feet apart, and had penetrated the soil to a depth of about 18 inches. The surface roots sloped gently downward toward the center of the row, where they were about 8 inches below the surface. At the time of the last cultivation, when the corn was nearly 3 feet high, the roots were found to occupy the entire soil down to a depth of about 2 feet, and the surface laterals descended in a gentle curve toward the center of the row and passed one another at a depth of only 6 inches. A third sample taken when the corn was coming into full tassel showed that the roots had fully occupied the upper 3 feet of soil in the entire field and that the surface laterals at this time had risen still higher, a few of them being scarcely 5 inches beneath the surface. At maturity the roots extended fully 4 feet into the soil and the upper laterals were within 4 inches of the top of the ground.

In studying the total root distribution of corn from 9 to 27 days old it was found that at the end of 9 days some of the roots had extended laterally to a distance of 16 inches, and that some had reached a depth of 8 inches. The tips of the longest roots were 6 inches below the surface and no roots were nearer the surface than 3 inches at 6 inches from the hill. Eighteen days after planting the tips of the longest roots had spread laterally to a distance of 18 inches and were 5 or more inches below the surface, while the longest roots extending downward had scarcely reached 12 inches, and at 6 inches from the hill no roots

were nearer the surface than 2 inches. Twenty-seven days after planting the greatest depth reached by the roots was 18 inches, and the greatest lateral extension 24 inches from the hill, with the tips 4 inches below the surface. The depth of the roots at 6 inches from the hill was the same as 9 days before.

In similar work along this line the North Dakota Station found that 30 days from planting the main roots appeared to have developed laterally and but few had penetrated to a depth of 12 inches, the bulk of the roots lying within 8 inches of the surface of the soil. An examination 55 days from planting, when the plants were 54 inches high, showed that the primary roots had penetrated to a depth of 2½ feet and that many of the horizontal roots now extended from hill to hill. The lateral roots frequently sent up feeders within 2 inches of the surface. A third sample was taken 90 days from planting and soon after the corn had been killed by frost. The roots at this time seemed to be still alive and growing. At this stage the roots had penetrated the ground to a depth of 3½ feet and they fully occupied the soil of the entire field. (See fig. 1.)

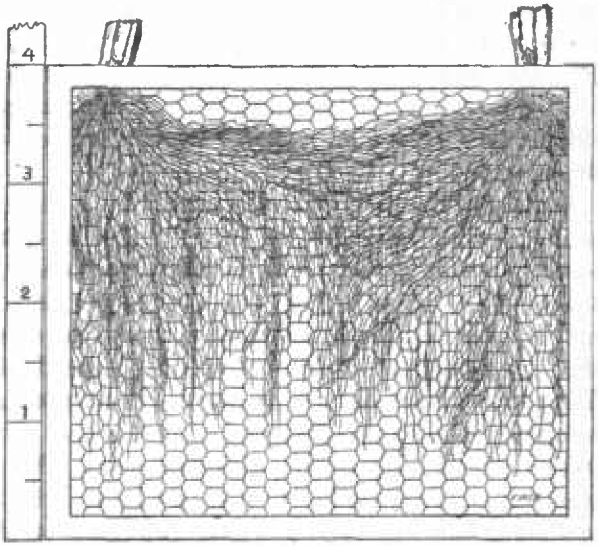

FIG. 1.—Root system of corn.

Very similar results are reported from the Colorado Station with corn grown on a mulatto sand. On a black adobe soil the roots grew mostly in the upper foot of soil, while in another heavy soil containing much clay they fed usually in its upper 2 feet of soil. Investigations in a rich sandy soil at the Minnesota Station show that in spring, when the surface soil is comparatively warm, the roots start out nearly horizontally, spreading 2 to 5 feet from the stalk. As the upper soil becomes dry they turn downward, attaining a length of 3 to 8 feet. The later roots grow more vertically downward from the time they start growth. The New York State Station found that in deeply prepared soil corn roots penetrate deeper than in shallow soil.

The Kansas Station found that the roots of corn are more extensive than those of Kafir corn and sorghum. Kafir corn showed a thick

growth of surface roots, while the root system of sorghum had a greater resemblance to that of corn. The roots of listed corn had developed at a uniform depth and the surface roots were uniformly deeper in the soil than in level-planted corn. It was also shown in these experiments that the roots of corn and other cultivated crops spread out farther, but did not grow so deep into the soil as the roots of wheat, oats, and barley.

All these experiments indicate that, by cultivating deeply, the large lateral roots of corn lying at a depth of 4 inches midway between the rows are likely to be broken. It is believed that as roots of listed corn lie deeper, corn planted by this method may be cultivated close to the hill and 3 to 4 inches deep at the last cultivation without injury to the roots, while in level-planted corn, the roots rising nearly to the surface several inches from the hill are destroyed by close cultivation. Deep cultivation for the purpose of forming a thick soil mulch is considered necessary, however, for the last cultivation of corn in hot and dry climates.

Small grains.—Wheat roots examined 110 days after sowing the seed at the North Dakota Station were found to extend directly downward, sending out numerous small feeders which practically occupied the soil to a depth of about 4 feet. In later experiments the roots of durum and bread wheat reached a depth of more than 4 feet, and again showed that the system of rooting is vertical instead of lateral, as in corn. The root development was greater in the durum than in the bread wheat samples. It was also observed that the root development in cereals varied considerably during different years. The root system of oats was found to be similar to that of wheat, but the roots were longer and more numerous and extended fully as deep into the ground. The roots of emmer resembled those of wheat and extended to about the same depth. A sample of winter rye taken July 7 showed that the roots had reached a depth of only 3 feet, and that their development was smaller than in other samples of cereals generally. It is believed that early in the season the soil in the latitude of the station is too cold below a depth of 3 feet to admit of root growth. At the Kansas Station oats and barley produced a large fibrous growth of roots in the surface soil, but this was not equal to the growth of fibrous roots in the upper soil made by some of the perennial grasses.

Flax root system.—The North Dakota Station found the root system of flax quite unlike that of the other plants studied. It consisted of a single small thread-like tap root running vertically downward and giving off small short side roots in the first 12 to 18 inches. The tap root reached a depth of 3 to 4 feet. Unlike the roots of the other plants, the flax roots did not form a network near the surface of the soil, nor did they occupy it so completely.

Root systems of grasses.—The North Dakota Station also examined the roots of 1 and 2 year old plants of *Bromus inermis* and found that at 1 year old the roots had attained a depth of over 4 feet and formed a good sod, while the roots of the 2-year-old grass had reached a depth of at least 5½ feet. In comparing the root systems of native prairie grasses, timothy roots, and the roots of *Bromus inermis*, it was found that the roots of the native prairie grasses did not make as heavy a sod as the cultivated ones, and that the roots examined reached less than 3 feet in depth. In later work a brome grass specimen taken from a 3-year-old sod showed the densest rooting of all samples of cereal and forage crops. Native slender wheat grass, also from a 3-year-old sod, did not have the strong root growth of the brome grass although its root system was heavier than that of any other crop studied. The Kansas Station also found that the largest growth of fibrous roots in the surface soil was made by the perennial grasses as compared with cereal and other crops, and that certain species also extended their roots deeper into the soil than any other class of crops except perennial leguminous plants.

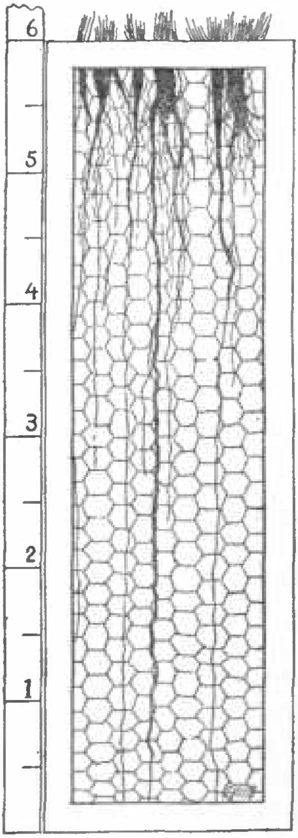

FIG. 2.—Root system of alfalfa.

Root systems of legumes.—At the Kansas Station alfalfa was the deepest-rooted crop studied. The plant developed only a small growth of fibrous roots near the surface, the principal root development being deeper in the soil. (See fig. 2.) Cowpeas and soy beans appeared to be light-rooting crops. At the North Dakota Station the roots of red clover during two years of development grew down over 4 feet and quite fully occupied the upper 3 feet of soil. Crimson clover roots in a single season attained a depth of 3 feet by August 22.

Potato root system.—Samples of an early and late variety of potatoes at the North Dakota Station showed that the main portion of the root growth of this plant is shallow. Forty-three days after planting the principal part of the root development was found to lie within 8 inches of the surface of the ground. The lateral roots had extended from hill to hill and interlaced. Some of the principal lateral roots were

found to be only $2\frac{1}{2}$ inches from the surface at 6 inches from the hill. This root development indicates the necessity of shallow cultivation of the crop, and this was confirmed in experiments with deep and shallow cultivation, the results showing a decided advantage for the shallow cultivation of potatoes unhilled. It was also shown that late potatoes root more freely and more deeply than early ones, and as a result will not stand as close planting as the early varieties. When the hills are about 3 feet apart each way the soil is very fully occupied by the roots to a depth of 3 feet.

Sugar-beet root system.—Sugar-beet plants examined by the North Dakota Station at maturity, or 133 days after planting the seed, presented a deep root extending almost perpendicularly downward into the ground, the lower part being quite small and thread-like and reaching to a depth of more than 3 feet, and the lateral roots starting 4 or 5 inches from the surface with but little root development in the upper 6 inches of the soil. The greatest amount of branching and fibrous growth of beet roots took place in the space between 8 and 14 inches in depth. (See fig. 3.) The effect of subsoiling on the root growth and development of sugar beets, as studied by this station, resulted in a considerably better development of feeding roots and a more symmetrical development of the main root on the subsoiled plats. The Kansas Station also found that the root system of the sugar beet lies comparatively deep, and that the crop therefore admits of deep cultivation.

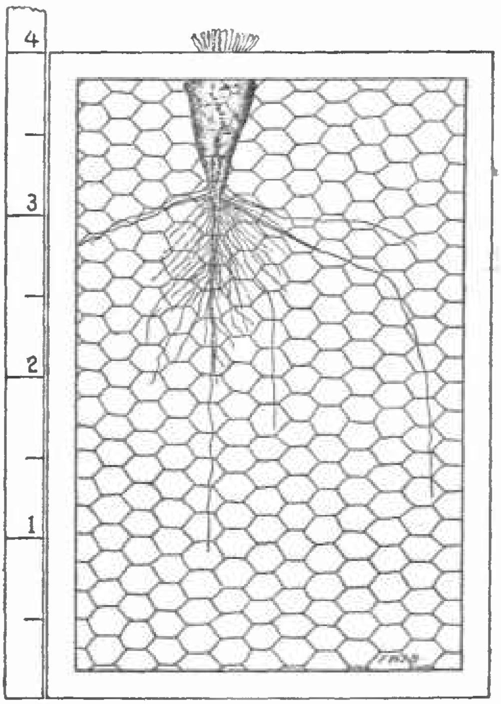

FIG. 3.—Root system of sugar beets.

This study of the roots of plants gives us a clearer idea of the proper methods of preparing and cultivating the soil for the different field crops. In general, root systems of crops like corn, potatoes, beets, beans, etc., reach from row to row and near the surface and hence should be given shallow cultivation, though beets may be cultivated deeper than the other crops mentioned. The roots of cereals, grasses,

clovers, and alfalfa grow more directly downward and generally reach deeper into the soil than the cultivated crops.

FERTILIZERS FOR ASPARAGUS.[a]

Salt was long considered an essential fertilizer for asparagus. The natural habitat of asparagus is the seashore, and it was reasoned, therefore, that salt was beneficial to this crop. In modern commercial practices, however, beds of asparagus have been found to yield as well without salt as with it, and this has raised the question whether the use of salt is to be considered essential in the culture of asparagus.

E. Walker, of the Arkansas Station, has recently made an experiment to determine the value of salt in asparagus culture. One-half of a bed containing one-seventh of an acre was fertilized with salt at the rate of 1,000 pounds per acre. The asparagus field was in its second year at the time the experiment was started. As far as could be seen there was no appreciable effect of the salt upon the growth of the asparagus nor in preventing the growth of weeds. The following spring that portion of the field which had received salt the preceding summer was again salted, and this time at the rate of 2 pounds per square yard. The salt was applied in two equal portions at intervals of 20 days. With each variety of asparagus larger stalks and an increased yield was secured where the salt was applied, the average increase being 13.5 per cent in favor of the salted area. Not only was the growth of the stalks increased in the spring, but there was also an increased vigor manifested in the plants throughout the summer and a notably increased glaucous appearance in the salted plants. The salt was entirely effective in preventing the growth of weeds. On the salted area without any hoeing but few weeds appeared, and those late in the season. This beneficial action was believed to have been beyond what might have been assigned to the salt in simply preventing weed growth. The results indicate that while in the field culture of asparagus salt may not be especially useful, in the small garden patch, where intensive culture is practiced and where large amounts of stable manure are applied each year, it may answer a very useful purpose, especially in keeping down weeds.

There has been some question as to whether or not early spring applications of fertilizers will affect the yield of merchantable shoots the same season. As is well known, the food supply of the first shoots to appear in spring is largely derived from food stored in the roots the preceding season. C. P. Close, of the Delaware Experiment Station, reports the results of an experiment in which the value of spring appli-

[a] Compiled from Arkansas Sta. Bul. 86; Delaware Sta. Rpt. 1902, p. 89; New Jersey Sta. Bul. 173, Rpt 1904, p. 316; Rhode Island Sta. Bul. 96.

cations of nitrate of soda were studied. In the experiment a half acre of asparagus was fertilized with 100 pounds of nitrate of soda, which was applied in four equal portions at intervals of about 10 days. The first application was made about 10 days or 2 weeks before the cutting season began. Another half acre was left unfertilized for comparison. The yield of stalks from the fertilized plat was 460 pounds and from the unfertilized plat 448 pounds, a difference of only 12 pounds in favor of the fertilized plat. This slight difference might or might not have been due to the use of the fertilizer, but "even admitting that the gain of 12 pounds is due to the 100 pounds of nitrate of soda used, it is not enough gain to justify the use of the fertilizer." The station concludes that "the use of nitrate of soda on asparagus beds during the cutting season can not be recommended." On limed soil at the Rhode Island Station nitrate of soda has proved nearly twice as valuable a fertilizer for this crop as sulphate of ammonia.

A. T. Jordan reports fertilizer experiments with asparagus which have been under way at the New Jersey Experiment Stations for seven years. The asparagus field is situated on a gravelly clay loam. Plat 1 is fertilized with 20 tons of manure per acre, applied at setting and thereafter in fall or early winter. Plat 2 is given a complete fertilizer consisting of a mixture of the best forms of fertilizing constituents, analyzing 4.5 per cent nitrogen, 7.7 per cent available phosphoric acid, and 13.3 per cent potash, applied at the rate of 500 pounds per acre in the spring. Plat 3 is fertilized with the same fertilizer and in the same way as plat 2, and is given in addition a mixture of equal parts of ground bone and muriate of potash, applied at the rate of 300 pounds per acre in the fall. Plat 4 is fertilized with the same mixtures and in the same way as plat 3, and in addition is given 200 pounds of nitrate of soda per acre about July, or at the end of the cutting season. The average yields obtained from the plats differently fertilized and the cost of fertilizing each plat is shown in the table on page 13. Like data are also shown for the crop of 1903, which is taken as representing more nearly the results in a mature field.

Yields of asparagus with different fertilizers.

Plat and kind of fertilizer.	Average first 6 crops.				Crop of 1903.		
	Average annual cost of fertilizer.	Total yield.	Value at 11.2 cents per pound.	Value less cost of manure or fertilizer.	Total yield.	Value at 13.1 cents per pound.	Value less average cost of manure or fertilizer.
		Pounds.			*Pounds.*		
Plat 1, manure	$45.38	2,941.7	$329.47	$284.09	5,231.3	$685.30	$639.92
Plat 2, complete fertilizer	12.93	3,000.2	336.02	323.09	4,807.9	629.83	616.90
Plat 3, complete fertilizer+bone and potash	18.92	2,605.4	291.80	272.88	4,060.6	531.94	513.02
Plat 4, complete fertilizer+bone, potash, and nitrate of soda	24.91	2,384.9	267.11	242.20	3,974.9	520.71	495.80

The table shows that the largest total average yield has been obtained from plat 2. The cost of the fertilizer for this plat has also been less than for any other plat and a little more than a fourth as much as for the plat fertilized with manure. The addition of bone and potash or of bone, potash, and nitrate of soda to the complete fertilizer, as in plats 3 and 4, increased the eost of the fertilizer per aere without giving any inerease but rather a decrease in yield. Considering the 1903 crop alone, the largest yields and greatest net financial returns were obtained from the plat fertilized with manure. The following year also the largest yields were obtained on the plat fertilized with manure.

Summarizing briefly, the investigations at the various stations indicate that salt may be used with benefit in the small asparagus bed of the garden and that early spring applieations of nitrate of soda are not likely to be of benefit in seeuring an inereased eut of stalks the same season. As regards eommercial fertilizers and barnyard manure for asparagus, if the land is in good condition a well-balaneed eommereial fertilizer may produee as good yields as manure and may be eheaper.[a]

GROWING MUSHROOMS FOR HOME USE.[b]

Edible wild mushrooms may be found in abundance in pastures and woods throughout the growing season. but espeeially during the autumn months. Attention has been called to these wild forms by a number of the experiment stations, and many well-illustrated bulletins have been published on the subjeet. Many people are deterred, however, from the use of this desirable edible[c] beeause of a fear of aceidentally gathering the poisonous kind.

[a] For a complete account of asparagus culture, see U. S. Dept. Agr., Farmers' Bul. 61.

[b] Compiled from New York Cornell Sta. Bul. 227.

[c] For an account of the food value of mushrooms, see U. S. Dept. Agr., Farmers Bul. 79, p. 18.

The cultivated mushrooms are not grown as yet to any great extent in the United States. They may be had in cities and in limited quantities in some of the larger towns, but are usually scarce and expensive. Many people who would enjoy having mushrooms added to the home menu are debarred because of the difficulty of obtaining them except at considerable expense and because of unfamiliarity as to methods of home culture.

Owing to the increased interest in mushrooms G. F. Atkinson and R. Shore, of the New York Cornell Station, made a study of methods of mushroom culture on a small scale and have recently reported the results of this work in bulletin form. The main purpose of the work was to find out by actual trial what success might be expected by the beginner in growing mushrooms where no special houses and no elaborate preparations were made for their culture. Based on this work the following cultural directions are given:

Cellars or basement rooms where the temperature in the winter does not go below 55° or does not rise above 65° are suitable places for growing mushrooms. It is not advisable to make them under the living part of the house, since the odor of the manure will fill the house. They can also be grown in stables which are not too cold in the winter. * * * Beds can be prepared on the cellar or basement floor by using the wall for one side of the bed. A board or plank 1 foot to 15 inches in width can then be stood on edge 3 to 4 feet from the basement wall and held in position by the necessary upright scantlings and supported at intervals to hold the material in position. In this way a box of the desired width and length can be made, the floor of the basement or cellar serving as the bottom. If more space is desired, tiers of beds can be made; that is, 2 or 3 or 4 beds one above the other against the cellar wall. This is a common practice. Crosspieces from the uprights can be nailed on, upon which the floor of the upper beds can be laid. These should be made of lumber at least 1 inch in thickness. A space of about 20 to 24 inches should be left between the top of one bed and the bottom of the one directly above it. All these places should have some ventilation, but there should not be air currents, and care should be taken to make the rooms in which the mushrooms are planted clean and sweet in order to avoid as far as possible any conditions which would encourage insects and other enemies of mushrooms.

Soil for mushrooms.—The best soil for mushrooms is that made from horse manure from well-bedded stables. While some straw is desirable, any large percentage is objectionable and should be removed. The manure is cured by putting it under cover in piles 3 to 4 feet deep and of any length and width. These piles soon begin to ferment and heat.

To prevent its becoming too hot, the manure must be forked over and made into a new pile. This is done by beginning at one end, turning the manure over, shaking it slightly as it is turned into the new pile. It may feel to the hand quite hot, but as long as it does not turn white or get too dry the heating will not harm it. Usually after the manure is well heated, turning once in 2 or 3 days will answer, but sometimes it is necessary to turn every day.

If the manure becomes too dry, sufficient water may be sprinkled on to make it moist but not wet. It usually requires 10 to 15 or 18

days to cure, but should not be put in the beds or boxes until the temperature has gone down to 100° F.

Preparation of the bed.—In the preparation of the bed a layer of the coarse, more strawy portion of the manure is first put on the bottom and then thoroughly tramped or pounded down. Succeeding layers are then put on and each packed down until the bed is 10 to 12 or 14 inches thick. For a few days after the bed is made, the temperature is likely to increase, after which it will gradually cool off. A thermometer should be kept in the bed several inches below the surface, and when the temperature falls to 70° or 75° F. the mushroom spawn may be planted. Sometimes 1 part of rich soil is used with 4 or 5 parts of manure in making up the beds. In such cases a little of the soil is added with each layer of manure.

Planting the spawn.—Cultivated mushroom spawn, used for planting the beds, may be obtained from nearly any seedsman in the form of dried manure bricks. Before using, it should be broken up into pieces about 2 inches in diameter. These pieces are planted in the bed 8 to 10 inches apart by making a suitable hole about 2 inches deep and pressing the spawn firmly into it. The hole should then be again filled with the manure and packed down firmly. The bed is then covered loosely with excelsior or straw to retain the moisture and to prevent a too rapid fall of temperature. At the end of about a week this material is removed and the beds are then covered over with an inch to an inch and a half of rich loamy soil.

The object in casing the beds with soil is to retain the temperature within the material, which is necessary for the maintenance of the growth, and it also provides a firmer and cleaner substratum in which the stems of the mushrooms are mostly formed and they are thus cleaner when picked. In from 6 to 7 weeks mushrooms should begin to appear.

Harvesting and yield.—Mushrooms are ready to pick about the time the gills beneath the umbrella portion are a bright pink color. They remain in an edible condition until the gills become dark brown or even black, providing they are not decayed. If a hole is made in the bed in removing the mushrooms it should be filled in again with soil. The beds will need an occasional sprinkling with tepid water, but should not be made very wet. Too much moisture causes the mushrooms to damp off or rot.

The yield of mushrooms at the New York Cornell Station was at the rate of about 2 pounds per square foot of surface. The manure for the beds was composted the last of October and the beds spawned November 23. The first mushrooms were picked January 1, or about 5 weeks after spawning the beds. A week later regular picking began, and the beds continued in bearing for about 3 months.[a]

[a] For a further account of mushrooms, see also U. S. Dept. Agr., Farmers' Bul. 204.

ONION CULTURE IN THE SOUTHWEST.[a]

Some interesting details of practical value relative to cultural methods and irrigation for onions, especially for regions of deficient rainfall, have recently been reported in bulletins from the Texas and New Mexico experiment stations.

The work reported from Texas by J. K. Robertson and E. C. Green was carried on in the southern part of the State at the substation at Beeville, where fair crops of onions are secured without irrigation. The purpose of the experiment was to determine the relative cost and yields of irrigated and unirrigated onion crops. The seed was started in beds and later transplanted to the field. At transplanting time the tops were cut back to about 5 inches, as shown in figure 4, and the roots trimmed to about three-fourths inch long.

FIG. 4.—Onions trimmed for transplanting.

The soil was a rich black loam containing some sand. It was prepared by plowing, in September, 7 inches deep with a disk plow. On December 17 it was again plowed 6 inches deep and harrowed. On January 30 furrows 2.5 feet apart were laid off, and water applied over the whole field at the rate of 40,000 gallons per acre. Three days later the field was leveled, cultivated, and planked. The following day the onions were set out. From then on until the first of May, or about a week before harvesting, frequent shallow cultivation, about 1.5 inches deep, was given. In all, eight cultiva-

[a] Compiled from Texas Sta. Bul. 77; New Mexico Sta. Bul. 52.

tions and one hoeing were given. The aim was to keep the ground broken up after each rain and maintain a dust mulch to preserve moisture. The preliminary irrigation over the whole field was necessary because of an unusually prolonged drought. Ordinarily it would not be needed. One part of the field received no further irrigation. The other part was irrigated four times, using water at the rate of 30,000 gallons for the first three irrigations and 40,000 gallons for the last. The rainfall from November 5 to May 6, when the crop was harvested, was 8.23 inches.

The cost of growing onions without irrigation was at the rate of $72.86 per acre, and the yield obtained was at the rate of 350 bushels per acre. With irrigation the cost was at the rate of $97.96 per acre and the yield at the rate of 676 bushels per acre. Irrigation in this instance increased the yield 326 bushels per acre at an increased cost of only about $25.

In this experiment the engine used for pumping water was insufficient, and at times the crops suffered from need of moisture. Otherwise, it is believed there would have been a still greater difference in yield in favor of irrigation.

Tests of varieties of onions suitable for the district have been made for a number of years at the station, the results of which show the Bermudas to be the most desirable and profitable, the red Bermuda giving uniformly the best satisfaction.

Sowing onion seed in beds or cold frames and later transplanting to the field has also been found by F. Garcia to be more satisfactory in New Mexico than sowing the seed in the field. However, practically all the onions now grown in New Mexico are from seed sown in the field. When sown in beds and transplanted from 3 to 4.5 pounds of seed are required, while if the seed is sown directly in the field 4 to 6 pounds are required. At that station it has been found better to transplant the latter part of February or early in March, even if the onions are only one-half as large as a lead pencil, than to wait until later in the season. It has been found that a boy can drop the onions for about three planters. A good planter will set 5,000 plants per day. With hand cultivation it is recommended that the rows be about 15 inches apart and the onions set 4 to 4.5 inches distant in the row. With horse cultivation the rows should be about 30 inches apart. The relative merits of these two methods of culture have been discussed in an earlier bulletin of this series.[a] The average estimated cost at the station for transplanting, for a period of three years, has been about $30 per acre, while the cost of thinning onions grown from seed in the field has been $41 per acre.

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[a] U. S. Dept. Agr., Farmers' Bul. 149.

In the region of the New Mexico Station the rainfall is so light that onions can not be grown without irrigation. The following suggestions are therefore made relative to irrigation:

Immediately after the onions are set out they must be irrigated, and this should be followed with a second irrigation in about 7 to 8 days. Usually it takes about two irrigations to establish the little plants. The subsequent irrigations will vary more or less, depending on the soil and climatic conditions. Other things being favorable, the time between the irrigations to get good results should be about every 8 to 12 days. Since the onion is a surface feeder, it is very desirable that the upper portion of the soil be kept moist and cool. If possible, the plats should be arranged so that any excess of water may be drained off after each irrigation, especially on adobe soils. Care should also be taken not to allow the water to stand too long on the land. The soil must be kept uniformly moist throughout the growing period of the onion. If the soil becomes so dry that the plants stop growing and is then irrigated, the tendency is for many of the onions, especially if this occurs after the bulbs have made a considerable growth, to split into two or more parts. If this occurs, a part of the crop is liable to become unsalable.

Light and frequent irrigations are preferred to heavy irrigations at long intervals. Good results have been secured when very muddy water was used for irrigating purposes.

The yield of different varieties at the station in 1903 without fertilizers was at the rate of 32,000 pounds per acre for Red Victoria and 29,000 pounds for Prize Taker. In 1904 the variety Gigantic Gibraltar without fertilizer yielded at the rate of 31,250 pounds per acre. When nitrate of soda was used at the rate of 600 pounds per acre with this variety the yield was 40,450 pounds, an increase of 9,200 pounds per acre due to the use of nitrate of soda. The cost of growing an acre of onions in New Mexico varied from $107 to $111.75 per acre without fertilizers. The cost of cultivating and irrigating alone averaged about $30.

THE USE OF ETHER IN FORCING RHUBARB.[a]

Most of our northern flowering shrubs shed their leaves in the fall and ripen up their wood in preparation for a winter resting period. In 1893, Johannsen, of Denmark, discovered that if such shrubs were subjected to the fumes of ether for a certain time at the beginning of the resting period they could be placed in the greenhouse immediately thereafter and forced at once, coming into bloom about a month earlier than they otherwise would. This fact has been found of considerable commercial importance to European florists, who are more and more using this method for securing extra early blooms, especially with lilacs.

Recently W. Stuart, of the Vermont Station, has reported results of experiments in forcing rhubarb by the aid of ether fumes.[b] In

[a] Vermont Sta. Rpt. 1904, p. 442.

[b] The Rhode Island Station has reported the results of forcing rhubarb in cellars in winter, as stated in U. S. Dept. Agr., Farmers' Bul. 107, p. 13.

these experiments the roots were dug in the fall and allowed to freeze. About mid December they were put in a cool cellar, where they thawed out gradually, after which part of the roots were subjected to the fumes of ether and part left untreated for comparison. The roots were etherized for forty-eight hours in an air-tight box, using ether at the rate of 10 cubic centimeters per cubic foot of space. The method of applying was to pour the liquid through a small hole in the cover of the box into a vessel suspended beneath the opening, after which the hole was immediately closed. Three other lots of roots were later etherized in the same manner, one lot January 9, another January 30, and the third February 24. With the roots treated January 30, 17 cubic centimeters of ether per cubic foot of space was used. This was later found to be too much, as the plants were injured by the treatment.

Comparing the three lots, which were all treated with like amounts of ether, the following results as regards early and total yield were obtained:

Yield of rhubarb treated with ether fumes.

Treatment.	First picking.	Second picking.	Third picking.	Total.	Gain by etherization.
Lot 1:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Per cent.*
Etherized December 20	454	681	340	2,294	34.4
Not etherized	69	246	378	1,707	....
Lot 2:					
Etherized January 9	270	449	608	1,914	89.7
Not etherized	....	209	395	1,009	....
Lot 4:					
Etherized February 24	21	343	189	553	5.7
Not etherized	34	336	153	523	....

The table shows that the etherized plants gave the largest total yield in every instance. This is not marked in the case of the lot etherized February 24. The exception in this case was not unexpected, since European experiments with other plants have shown quite uniformly that the later etherization is deferred during the resting season the less effect it has. Plants that have completed their resting period have not usually been benefited at all by etherization.

If early yields are considered, the average of the three lots shows an increased gain in earliness of the etherized plants of 622 per cent for the first picking, 86 per cent for the second, 23 per cent for the third, and 47 per cent for the fourth. The more rapid growth made by the etherized plants may be plainly seen in figure 5, which shows the condition of the etherized and unetherized plants just before the first picking was made.

In summing up the results of the season's work it would seem quite evident that there was a decided impulse given to the ether-treated dormant plants. This quickening of the vital processes in the plant resulted in a more vigorous growth

and a decided increase in weight of product. From the data at hand it would seem reasonable to assume that even more satisfactory results might have been attained had the work been undertaken a month or six weeks earlier. It is probable also that etherization of the plants would serve the same purpose that freezing does and in addition produce a greater growth.

FIG. 5.—Etherized and untreated rhubarb.

Caution must be observed in the use of ether fumes, since the gas readily explodes if brought in contact with a light fire.

NOODLES.[a]

A report of the Connecticut State Station states that "noodles are prepared by European housewives and some manufacturers from flour, with the addition of a certain amount of eggs and salt. The dough is rolled into sheets and cut into strips or fanciful shapes. Most of the noodles on the market, however, although of a golden yellow color, are not made with eggs, but have about the same composition as macaroni, being dyed either with a vegetable color (commonly turmeric) or a coal-tar dye."

Twenty-two samples of noodles were collected and analyzed by the station during 1904, and all were found to "contain foreign coloring matter, which in twelve cases was turmeric and in ten cases was an azo color," evidently added with the intention of conveying the impression that the noodles were made with eggs, or contained a greater amount of eggs than was actually used.

The average composition of the noodles examined was water 12.94 per cent, ash 0.88 per cent, protein 13.46 per cent, nitrogen-free extract (carbohydrates) 71.89 per cent, and fat 0.83 per cent, or about

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[a] Compiled from Connecticut State Sta. Rpt. 1904, pt. 2, p. 138.

the same as macaroni and but little different from that of the wheat flour from which it is prepared. Few of the samples examined showed any evidence of the use of an appreciable amount of egg in their preparation.

CONDIMENTAL FEEDS AND CONDITION POWDERS.[a]

A recent bulletin of the New Jersey Stations states that an examination of experiment station literature shows that hundreds of different brands of condimental feeds and condition powders are found in the markets of the United States, and that their number and the feeders using them are constantly increasing in spite of the fact that "the virtues and the failings of these preparations have been discussed many times by various investigators in this country and Europe, and their excessive cost and the doubtful benefits attendant upon their use clearly pointed out.[b] * * *

"The increasing use of these materials led [the] station in its 1904 inspection to collect all the different brands its inspector could find on the New Jersey market; as a result 50 different brands were found." Comprehensive microscopical and chemical analyses of these showed that they generally consisted of some well-known feeding material like linseed meal, wheat feed, or corn meal as a base, to which had been added varying amounts of vegetable or mineral drugs, ground bone, oyster shells, or some makeweight.

"The purpose of the use of drugs in these mixtures in most cases is to create an appetite, to tone up the system, or to act as a corrective on the bowels of the animal." It should always be borne in mind, however, that "animals in good health require no medicine; in fact, the excessive use of medicine with well animals frequently induces disorders. * * *

A loss of appetite, or a run-down condition induced by overwork or insufficient feed, may often be remedied by the use of a stimulating or tonic food, the ingredients for making which the feeder should always keep at hand. In the majority of cases simply a change of food will bring about the desired effect, but when this is ineffective a liberal use of common salt in the ration will generally prove beneficial. In the case of horses the use of linseed meal will be frequently found of marked benefit as a laxative.

The claims of the manufacturers of condimental feeds when not preposterous are exaggerated and misleading. No one feed, however skillfully compounded, can serve as a remedy for all the ailments of all classes of live stock.

Instead of being prepared according to scientific formulas as claimed, many of the condimental feeds are heterogeneous mixtures, with little regard to the requirements of the animal, and in certain cases the drugs used have a counteracting effect on each other.

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[a] Compiled from New Jersey Stas. Bul. 184.

[b] See U. S. Dept. Agr. Farmers' Bul. 73, p. 25.

Even where effective drugs have been used the amount of the mixture to be given to the animal, according to the instructions of the manufacturer, is generally so small that no possible benefit can be expected from its use.

Assuming that the condimental feeds are scientifically prepared mixtures of useful and effective ingredients and their use as directed would confer upon the animal the benefits claimed, their excessive cost would prohibit their use by the careful and economical feeder. Such ingredients [as] they contain which might be of benefit any feeder can obtain and mix for himself at from one-tenth to one-twentieth the cost of the prepared foods. He would have the added advantage of knowing just what drugs he was administering to his animals and could give them such quantities of the needed medicines as veterinary experience has shown to be necessary.

BEEF TYPE v. DAIRY TYPE FOR BEEF PRODUCTION.[a]

The Iowa Station has recently reported the results of a year's feeding test to determine the relative economy for beef production of the beef and dairy types of cattle, a question which is receiving much attention at the present time. The results attained are summarized as follows:

Dairy type steers show a considerably higher percentage of offal and a lower dressing percentage.

Dairy type steers carry higher percentage of fat on internal organs, thereby increasing the total weight of cheap parts.

Beef type steers carry higher percentage of valuable cuts.

Beef type steers furnish heavier, thicker cuts; they are more evenly and neatly covered with outside fat, show superior marbling in flesh, are of a clearer white color in fat, and a brighter red in the lean meat; but there is little difference in fineness of grain.

The low price paid for dairy steers may be due partially to prejudice, and to the greater expense of carrying and selling the lower-grade carcasses; but it is chiefly due to an actual inferiority in the carcasses.

It is neither profitable nor desirable to feed steers of dairy type for beef purposes. They are unsatisfactory to the consumer because they do not furnish thick and well marbled cuts; they are unsatisfactory to the butcher because they furnish low-grade carcasses which are difficult to dispose of, and they are decidedly unsatisfactory to the feeder, because they yield him little or no profit, and both breeder and feeder waste their time in producing such a type of steer for beef purposes.

METHODS OF FEEDING SKIM-MILK CALVES.[b]

The increased use of milk separators in the dairy sections of the country has resulted in greater attention being paid to raising calves on skim milk. It is well settled at this time that practically as large, strong, and vigorous calves can be grown on skim milk supplemented by some suitable grain feed as on whole milk, providing they are properly fed and cared for.

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[a] Compiled from Iowa Sta. Bul. 81.

[b] Compiled from Idaho Sta. Bul. 48; Iowa Sta. Bul. 35; Kansas Sta. Buls. 97, 119, 126; Nebraska Sta. Buls. 68, 87.

There is no question but that whole milk is the normal food for calves, and when the cream or butter fat is removed it becomes necessary to replace it in the calf ration with some equivalent but cheaper form of feed. A number of the stations have made experiments with different feeds to learn which is most efficient for this purpose. Corn meal has been found the cheapest and best supplemental grain for this purpose at the Iowa Station. Whole corn and Kafir-corn meal have given good results at the Kansas Station. At the Nebraska Station germ-oil meal and linseed meal have proved efficient substitutes, and in a recent bulletin of the Idaho Station good gains with oats are reported.[a]

The method of procedure in rearing the skim-milk calf at the Kansas Station was about as follows: The calf was allowed to run with its mother the first 4 or 5 days of its life. It was then removed and left twenty-four hours without food, when it became hungry and was easily taught to drink. For a week thereafter it was fed whole milk at the rate of 4 pounds in the morning, 2 pounds at noon, and 4 pounds at night. The second week about the same amount of milk was given in two feeds, morning and night. Within two or three weeks after removal from the cow, skim milk was gradually substituted for whole milk at the rate of a half pint per feed until the entire amount was skim milk. About a month after the calf was taken from the cow it was receiving 12 to 14 pounds of skim milk; at two months, 18 pounds, and finally reached 22 to 24 pounds per day.

The grain added to the ration was fed dry in boxes. The calves began to eat grain when 10 days to 2 weeks old. At first a handful was put in the calf's mouth as soon as it had finished drinking its milk, and it soon learned to eat with a relish from the feed boxes. The Kafir-corn meal or other grain was never mixed with the milk. The calves were fed what grain they would eat up clean.

When the calves were 10 days to 2 weeks old they began to nibble hay and were thereafter fed all they would eat. The hay was given fresh twice daily. Some hay from mixed grasses is considered best, with bright prairie grass a close second. Clover and alfalfa may be gradually added to the ration after the calves are several weeks old. Alfalfa alone was found to be too loosening for young calves. Changes from dry hay to pasture must be made very gradually or the calves are almost sure to have scours. This is done by turning them onto pasture for only a short time the first day and gradually increasing the period, or by mixing increased amounts of green feed with their hay until they are getting about all they will eat.

The most convenient way of feeding the calves has been by putting them in stanchions. Here they were kept for a half hour after feeding

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[a] See also U. S. Dept. Agr., Farmers' Bul. 92, p. 21, for supplements to skim milk in feeding calves, and Bul. 84, p. 22, for experiments in Utah in rearing skim-milk calves.

until their mouths dried out and they had lost their desire to suck each other's ears. Fresh water was kept within reach of the calves all the time, and it was surprising to find how many times a day the calves took a sip.

Calves thus treated made an average gain of 1.58 pounds daily up to 5 months of age, results which are considered satisfactory. The cost of the gain in one test was at the rate of $2.26 per 100 pounds for skim-milk calves, $7.06 for calves fed whole milk, and $4.41 for calves running with their dams. When put in the feed lots the skim-milk calves made better gains than either of the other two lots.

Calves fed sterilized creamery skim milk made as good gains as when fed hand-separator skim milk. A proprietary calf meal and flaxseed meal were fed in addition to grain, but they did not increase the efficiency of the ration, besides being expensive and practically useless. No advantage resulted from adding rennet to the ration. Calves fed on buttermilk made average daily gains of 1.79 pounds per head as compared with 2.02 pounds for calves fed skim milk and were less subject to scours. Calves on whey made satisfactory gains where care was taken to feed suitable grain and hay rations in addition. Calves made better gains on shelled whole corn than on corn chop. With Kafir corn, however, the best gains were made on the ground grain. A mixture of corn and ground Kafir corn gave better results than either fed separately.

The management in the early stages of weaning the calf and substituting skim milk for whole milk at the Idaho Station was practically the same as at the Kansas Station. As soon as the substitution of skim milk for whole milk begins, the teaching of the calf to eat whole oats was undertaken. This was done by placing not more than a tablespoonful in the box in front of the calf after it had drunk the milk. In nosing about the calf got some of the oats in its mouth and in a very short time learned to like them.

Whole oats are preferred to rolled or ground oats, for the husk of the oat is then so thoroughly attached to the grain that it will be masticated with the kernel and the calf having sharp teeth will have no difficulty in grinding it. The ration of oats will be gradually increased as more of the whole milk is withheld and separator milk substituted until at the end of three or four weeks the calf will be getting half a pint twice a day. The amount depends on the calf, for some animals will eat the oats more readily than others. * * * After the calves have finished the ration of oats, which requires an hour or so, they are released [from stanchions] and allowed to pass into a box stall. This stall is provided with feed racks about the walls which are filled with the choicest hay the farm affords. The calves, even those only 5 or 6 days old, soon learn to pick this tempting bit of hay instead of sucking each other's ears, as they are apt to do when fed in the ordinary way.

Quite a difference was found by the station in the quality of oats for calves. Oats with a thin hull have been found best. Large, coarse,

thick-hulled oats were not so readily eaten and appeared to injure the calf's mouth. The average gain for the first 150 days for the calves thus reared at the Idaho Station was at the rate of 1.59 pounds per head per day.

Calves brought up on skim milk are most unattractive from 6 to 12 months of age.

They develop a stomacn out of proportion to the rest of their body and their coat is not quite as smooth as it is when calves run with their dams. However, the calves have learned how to eat and digest coarse feed in larger quantities than calves reared on whole milk. The digestive organs are better developed for practical feeding from this period on to maturity than in calves fed whole milk.

The following suggestions stand out prominently in the recommen- .tions by the stations: Make the change from whole milk to skim ilk slowly. Substitute about one-half pint of skim milk for whole ilk at each feeding until the calves are wholly on skim milk. Do t feed too much milk. The milk should be fed warm and sweet. he right temperature is between 85° and 100° F., and this should be termined by a thermometer rather than by the hand. The grain ould not be mixed with the milk, but be fed dry after the milk has been drunk.

Undoubtedly the greatest difficulty that the calf feeder has to contend with is scours. Here, as elsewhere, "an ounce of prevention is worth a pound of cure." he principal causes of this difficulty are overfeeding, sour milk, feeding cold milk, eding grain with the milk, using dirty milk pails, very cold water, too much water after periods of thirst, and irregularity in feeding. The careful feeder will watch very carefully the effect of his feed upon his calves, and as soon as there are ay signs of scours the milk should be reduced one-half or more and gradually creased again as the calf is able to stand it.

The Kansas Station has been very successful in using dried blood as a tonic for weak or scouring calves. A mild case of scours can usually be cured in from one to two days by reducing the milk and adding a teaspoonful of dried blood while the calf is drinking. * * *

In severe cases of scours the addition of one or two eggs with the dried blood has been found to be very effective. Another remedy that has been found to be successful is to give from 1 to 2 ounces of castor oil in the morning and follow in about twelve hours with 15 to 20 drops of laudanum and a teaspoonful of dried blood. If the case is a persistent one, one or two raw eggs may be added.

ANIMAL FOOD FOR DUCKLINGS.[a]

In an earlier number of this series[b] it was shown that, practically speaking, rations for ducks must contain some animal food. How much animal food it is best to give has been made the subject of further investigations by W. P. Wheeler, of the New York State Station. In a preliminary trial the station found that ducklings grew well for four weeks on a ration of which 94 per cent of the dry matter and 98

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[a] Compiled from New York State Sta. Bul. 259.

[b] U. S. Dept. Agr., Farmers' Bul. 97, p. 17.

per cent of the protein was derived from animal sources. The cost, however, was high. As the birds grew older the rate of gain became lower and the cost of production excessive. The experiment is interesting as showing how large a proportion of the ration fed to ducklings may consist of animal food without injury.

In a second experiment four lots of ducklings consisting of twenty-eight birds in each lot were fed for ten weeks a basal ration of grain so supplemented with animal meal and other foods that about 20 per cent of the protein in the ration of lot 1, 40 per cent of lot 2, 60 per cent of lot 3, and 80 per cent of lot 4 was derived from animal food. The gains made at different periods of growth, the amount of dry matter in the food required to produce a pound of gain, and the cost of the gains made are shown in the following table:

Average gain of ducklings on rations containing different proportions of animal food.

	Protein from animal products.	First 3 weeks of test.			First 7 weeks of test.			Entire 10 weeks of test.		
		Average gain.	Food per pound gain.	Cost per pound gain.	Average gain.	Food per pound gain.	Cost per pound gain.	Average gain.	Food per pound gain.	Cost per pound gain.
	Per cent.	*Oz.*	*Lbs.*	*Cts.*	*Oz.*	*Lbs.*	*Cts.*	*Oz.*	*Lbs.*	*Cts.*
Lot 1	20	15.9	2.5	3.6	56.3	3.0	4.2	71.7	3.9	5.4
2	40	19.1	2.2	3.3	64.2	3.0	4.6	78.8	4.0	6.0
3	60	22.5	2.1	3.3	68.4	3.0	4.7	82.7	4.0	6,2
4	80	20.8	2.3	3.8	66.2	3.1	5.2	78.7	4.2	7.0

The figures in the table show that throughout the entire test the most rapid gain was made by lot 3, where 60 per cent of the protein of the ration was derived from animal food, while the slowest gains were made by lot 1, which was fed the smallest amount of animal food. When the protein from animal sources was increased in the ration from 60 to 80 per cent, the gains were not so great; more food was required to produce a pound of gain, and the cost of the gains made was regularly higher throughout the whole period.

The table shows that the rations containing the larger proportions of animal food were most effective and most economically used during the early stages of feeding. Later on the rations containing the larger proportion of grain were fully as effective and considerably cheaper than those containing large amounts of animal food. Where it is desired to prepare birds rapidly for market, the ration containing the larger amount of animal feed is most efficient, and in certain cases this rapidity of growth may offset the increased cost of the larger meat ration.

So far as this one experiment goes, it seems from a study of the results that it will pay to feed freely of animal food during the first three to five weeks, and depend after that more on increasing proportions of the cheaper grain foods. The exact proportions most profitable to use will vary considerably at different times according to the food supply and the demand for the product.

MILK FROM DISEASED COWS.[a]

One of the most characteristic constituents of pus is the white blood cell or corpuscle, known technically as a leucocyte. Outside of the blood vessels these cells are found normally in various tissues and fluids of the body and so have gained the name of wandering cells. They are found abnormally and generally in large numbers wherever there is inflammation. They have been found in milk, and so the question has naturally been considered if their occurrence in milk indicates an inflamed or diseased condition of the udder. Information on this subject is contained in a recent bulletin of the Maryland Agricultural Experiment Station by C. F. Doane.

A method of counting leucocytes in milk was devised at the station and two large well-kept dairy herds were then systematically investigated. Leucocytes were found in the milk of every sample examined. Their numbers for individual cows ranged from 2,000 to 4,600,000 per cubic centimeter. As most of these cows at least must be considered as unquestionably in a state of perfect health the mere presence of leucocytes in milk does not therefore signify disease in the animal. Owing to the wide variation in the numbers of these leucocytes Doane considers it questionable if an arbitrary standard can be maintained beyond which it is safe to say that the milk contains pus, or in other words, that it is from a diseased cow and hence unfit for use. It was observed, however, that the milk of cows affected with garget showed in all cases a high leucocyte count, while the milk of healthy cows was often very low in the number of these cells.

Pursuing these studies further, Doane observed certain threads in pus which were identified as fibrin, and he was also able to find the same threads in the milk of diseased cows. In such samples of milk the fibrin threads and the leucocytes were present in masses or clumps. When the number of leucocytes in any sample of milk was low, no such clumps of leucocytes and fibrin were found. When the number of leucocytes was high, clumps were often present. A high leucocyte count would therefore render a sample of milk suspicious, and the presence of fibrin in addition, as shown by a clumping of the leucocytes or as demonstrated by staining the threads, would in the opinion of Doane furnish satisfactory proof that inflammation exists in the udder, and in such cases the milk of course must be considered unfit for use.

It is in reality not so much the purpose of this note to present the microscopical leucocyte-fibrin test of Doane, for whether or not this will prove of practical value in detecting the milk of diseased cows remains to be seen, but to call attention to a growing interest in the production and sale of clean, wholesome milk, and to this end methods

[a] Compiled from Maryland Sta. Bul. 102.

of inspection are being studied and applied. It behooves the dairyman to comply with the requirements of sanitary milk production and the consumer to insist upon the observance of these requirements.

CIDER VINEGAR.[a]

Vinegar is made from a number of different products. The best quality is made from fruit juices; cheaper grades are made from the malt, grains, and sugar refinery wastes and other sources. The cheaper kinds are often colored and otherwise "doctored" and then sold as cider vinegar. In order to prevent this fraudulent practice a number of States have passed laws establishing certain standards for vinegar. These laws are not entirely uniform. The minimum legal amount of acetic acid for cider vinegar is placed at 4 per cent in some States, in others 4½ per cent, and still others 5 per cent. The total solids likewise required vary in different States from 1½ to 2 per cent.

Under faulty methods of preparation it is not uncommon for vinegar made entirely from cider and wholly unadulterated to fall below these requirements. It therefore becomes important to note what the best methods of making vinegar under ordinary farm conditions are. The stations in Virginia, New York, Pennsylvania, and Oregon have all reported the results of valuable researches along this line, and the following account is based on their work.

Normal changes in vinegar production.—There are two important changes which take place in the conversion of fruit juice into vinegar. First, the sugar in the juice is converted into alcohol, and, secondly, the alcohol is converted into acetic acid. In these transformations 100 parts of sugar in the juice should produce theoretically about 51 parts of alcohol; that is, one should obtain about half as much alcohol by weight as there was sugar in the juice. In practice only from 45 to 47 per cent is actually obtained. In the conversion of alcohol into acetic acid 100 parts of alcohol should yield theoretically 130 parts of acetic acid, but less than 120 parts are actually obtained. Starting, therefore, with 100 parts of sugar in the fresh apple juice, under favorable conditions we should obtain from 50 to 55 parts of acetic acid. To make vinegar, therefore, which shall contain 5 per cent of acetic acid it will be necessary to have juice containing at least 10 per cent of sugar. For 4½ per cent vinegar, apple juice analyzing at least 8½ per cent of sugar will be necessary.

The composition of apple juice.—The juice of ripe apples has been found to vary in sugar content from 7 to 15 per cent, the average for

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a large number of varieties in different States being nearly 11 per cent. Analyses reported by the Virginia Station indicate that summer apples are on the average lowest in sugar content, winter apples highest, and fall apples intermediate. Mature ripe apples contain the largest amount of sugar; green apples contain a much smaller quantity, and overripe apples contain less sugar than ripe apples. Contrary to the usual belief, sweet apples are ordinarily no richer in sugar than sour apples. They taste sweet because they contain less malic acid than sour apples. Malic acid is the normal acid of apples. In vinegar making this acid disappears quite completely, decreasing in the case of experiments at the New York State Station from 0.55 per cent in fresh juice to 0.02 per cent at the end of twenty-four months, and in some older vinegars it had disappeared entirely.

Alcoholic fermentation.—In ordinary cellar storage it takes from one to six months for all the sugar in cider to become converted into alcohol. The more important factors affecting the rapidity of the transformation of sugar into alcohol are temperature and the presence of yeast. With a cellar temperature of 45° to 55° F. at the New York State Station it was six months before alcoholic fermentation was completed. In another cask kept at 85° F. alcoholic fermentation was completed in three months.

Alcoholic fermentation is caused by a vegetable ferment or enzym which is produced by ordinary yeast. Cells of the yeast plant are so widely distributed that they get into apple juice abundantly under ordinary conditions.

At a temperature of 65° to 75° F. the yeast plant grows much more rapidly than at lower temperatures. Hence fermentation is much more rapid. At a temperature much higher than this there may be a loss of alcohol by evaporation. The stations have found that the period of alcoholic fermentation can be readily reduced one-half or more by the addition of yeast to the fresh juice, especially if the cider is kept at a temperature of 65° to 75° F.

Acetic fermentation.—After alcoholic fermentation is completed another group of micro-organisms attack the alcohol and convert it into acetic acid. The acetic fermentation takes place much more slowly than the alcoholic, requiring eighteen months to two or three years before all the alcohol is changed into acetic acid when the cider is kept in ordinary cellar storage. The most satisfactory results of acetic fermentation were obtained at the New York State Station at temperatures of 65° to 75° F. When the micro-organisms causing acetic-acid fermentation were introduced into the cider at that station in the form of vinegar or "mother" after the alcoholic fermentation had been completed, the conversion of the cider into vinegar was much more rapid than where no addition of vinegar was made.

In a cool cellar, cider that had thus been inoculated by the addition of cider vinegar or "mother" reached marketable condition a year sooner than where the vinegar was not added. Vinegar should never be added to cider that has not completed its alcoholic fermentation, since the presence of the acetic acid greatly retards alcoholic fermentation. On this point Browne, of the Pennsylvania Station, states as follows:

Many farmers and vinegar manufacturers make a foolish practice of adding fresh apple juice to old vinegar stock in the hope of thus securing a more rapid conversion of the product into vinegar and then complain that their vinegar "won't make." The sugar of the juice must first undergo the alcoholic fermentation before the acetic fermentation can begin, and by adding apple juice to old vinegar the alcoholic fermentation may not only be checked but even absolutely prevented.

The organisms causing acetic fermentation require abundance of air in order to do their best work. The practice, therefore, of inserting an empty bottle in the bunghole of a barrel intended for vinegar is useless and injurious, as it prevents the free entrance of air, which is necessary for the growth of the acetic micro-organism. After acetic fermentation is completed the organisms are no longer needed. Barrels containing vinegar should then be filled full and tightly bunged, otherwise these organisms or others of a like nature may attack and destroy the acetic acid already formed, rendering the vinegar weaker or entirely worthless. At the New York State Station some of the uncorked vinegar finally actually became alkaline.

Suggestions for making vinegar.—The foregoing facts relative to the alcoholic and acetic fermentation lead to the following practical suggestions on vinegar making: Use only ripe, sound fruit. If the fruit is dirty it should be washed, otherwise there is danger of introducing micro-organisms into the juice that will interfere with the normal alcoholic and acetic fermentation. For the same reason cleanliness should also be observed in grinding and pressing the fruit and in the handling of the juice.

For profit the pressing should be done with a power press. With a hand press only 2 gallons of juice per bushel of apples could be secured at the Virginia Station, while with a power press 4 gallons were obtained. Sometimes water is added to the pomace and a second pressing made. Such juice is deficient in sugar and will not make vinegar of a standard quality. When possible, the freshly pressed apple juice should be placed in some large receptacle and allowed to stand for a few days before putting into barrels.

In this way considerable solid matter held in suspension will settle before the liquid is placed in casks. The casks used should be well cleaned, thoroughly treated with live steam or boiling water, and should not be over two-thirds or three-fourths filled with apple juice. The bung should be left out, but a loose plug of cotton may be placed in the hole to decrease evaporation and prevent dirt falling in. The bung should be left out until 4.5 to 5 per cent of acetic acid has formed.

When fresh cider is placed in barrels and stored in ordinary cellars, alcoholic fermentation is not completed until the end of about six months. With a cellar temperature of 60° to 70° F. this time can be considerably reduced. If yeast is added to the fresh cider, fermentation can be completed in three months or less. If compressed yeast is used about one cake to each 5 gallons of juice should be used after first thoroughly softening the yeast with lukewarm water.

The New York State Station advises that after alcoholic fermentation is completed the clear portion of the liquid be drawn off, the barrel rinsed out, and the clear liquid put back. From 2 to 4 quarts of good vinegar containing more or less "mother" should then be added. If the barrel is stored in a cool cellar it will require twenty-one to twenty-four months or more to change all the alcohol into acetic acid. If the alcoholic fermentation takes place in a cool cellar over winter and the barrel is moved into a warm place, as out of doors, during summer the acetic fermentation may be completed in fifteen to eighteen months. If the alcoholic fermentation is hastened by the addition of yeast and storage in a warm temperature, and the acetic fermentation favored by the use of vinegar "starter," as noted above, it is possible to produce good merchantable vinegar in six to twelve months.

When the acetic fermentation has gone far enough to produce 4.5 to 5 per cent of acetic acid, then the barrels should be made as full as possible and tightly corked in order to prevent destructive fermentation of acetic acid and consequent deterioration of the vinegar.

Rapid method of vinegar making.—The long time required to make vinegar by the cask and storage method, as described above, has led to the use of vinegar "generators," by the aid of which the acetic fermentation can be completed within a few days or even hours. These "generators" consist, essentially, of an upright cask 3 to 6 feet in diameter and 6 to 12 feet high. About a foot from the bottom of the cask there is a perforated false bottom, upon which coiled beech shavings which have been previously boiled in water, dried, and soaked for several hours in old vinegar are placed. Another perforated disk is placed above the shavings and the top closed with a cover containing a hole in the center, through which cider which has undergone complete alcoholic fermentation enters. Just underneath the false bottom a row of holes slanting downward is bored around the cask for the admission of air.

In operation the liquid flows slowly through the opening in the top upon the perforated disk where it is evenly distributed over the shavings. The rate of flow is regulated according to the size of the generator, but usually should not exceed 1 gallon per hour. The liquid flows in thin films over the shavings, coming in contact with the acetic-acid ferment and large quantities of air, which rapidly convert the alcohol into acetic acid. During the generation of vinegar the tem-

perature inside the cask rises. This is recorded by a thermometer inserted in the shavings in the middle or near the top of the cask. A temperature of about 95° F. near the top has been found to give the best results. At a higher temperature some loss of alcohol may occur by evaporation. The temperature may be lowered by plugging up some of the air holes from below and thus decreasing the air supply.

Vinegar thus made is likely to be more uniform in composition than that made in casks.

It is admitted, however, that generator vinegar, in aroma and flavor, is not equal to vinegar made by the longer process—the delicate and volatile ethers, which give the latter vinegar its peculiar properties, being the products of a slower and less violent fermentation. For a table vinegar the old process of fermentation is to be preferred, while for pickling and similar uses generator vinegar is no doubt as well suited as a product of the former kind.

The New York State Station notes that "in the hands of the ordinary farmer, making only a few barrels of cider, these generators would probably not be found entirely practicable in every way."

Vinegar from prunes.—Vinegar was made at the Oregon Station from undersized and otherwise unsalable prunes. The prunes were first washed and then run through a home-made machine with spike rollers, which lacerated and tore them. The pulpy mass was then inoculated with a pure culture of yeast (*Saccharomyces cerevisiæ*). This caused a strong and rapid fermentation, which broke down the cell walls of the prunes, thus liberating the clear juice, which flowed into a receptacle below the vat. This method of securing the clear liquid was inexpensive and very satisfactory. A little more than 3 gallons of juice was secured per bushel of fruit. The juice was fermented in open barrels. Fermentation was completed in ten days, when the juice was found to contain 10 per cent of alcohol. It was then inoculated with a pure culture of vinegar ferment (*Bacillus pasteurianus*) by floating it on the surface of the liquid by means of pieces of cork weighted so as to bring the culture in contact with the liquid.

The vinegar thus produced was of excellent quality, with a fruity flavor and good body, and contained 6.89 per cent of acetic acid. The only objection to it was its color, which was that of very dark wine. It was, however, but little darker than imported malt vinegars, which find ready sale in Oregon markets. By the use of yeast for the alcoholic fermentation and the addition of vinegar "starter" after the acetic-acid fermentation, pear vinegar containing 8.89 per cent acetic acid and apple vinegar containing 6 per cent have been made at the station within four months from the time the fruit was pressed.

The station states the essentials of vinegar making, thus:

The barrels must be free from must and mold, the depth of the liquid should not exceed the surface measure, free air must be continually admitted, an even, warm temperature should be maintained, and, last but not least, the fruit that is used should be free from decay and mold.